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CONTRIBUTIONS TO THE LIFE-HISTORIES OF PLANTS.

BY THOMAS MEEHAN.

Amphicarpœa monoica.—" Flowers of two kinds—those of the upper many-flowered racemes perfect and petaliferous, but seldom maturing fruit, those near the base of the stem on prostrate branches imperfect, but usually fertile." Thus writes Torrey and Gray, and this I think is usual experience. Mr. Darwin, says in "Forms of Flowers" "In three of the genera (*Leguminosœ* known to produce cleistogamic flowers) namely *Vicia, Amphicarpœa,* and *Voandesia,* the cleistogamic flowers are produced on subterranean stems. The perfect flowers of *Voandesia,* which is a cultivated plant, are never said to produce fruit, but we should remember how often fertility is affected by cultivation." (Chap. VIII, p. 327) "Although cleistogamic flowers never fail to yield a large number of seeds, yet the plants bearing them usually produce perfect flowers, either simultaneously or more commonly at a different period, and these are adapted for or admit of cross-fertilization" (ibid p. 340).

I had often gathered the seeds, near the ground on plants growing in shaded woods and thickets, and supposed I was familiar with it. In December of 1886, walking along the banks of the Wingohoccing creek, which runs through my farm, I noted quantities of dry legumes on dead vines that had profusely covered masses of blackberry bushes. I could have gathered pounds of seed. I had never seen *Amphicarpœa* in this condition, and was so completely off my guard, that I was amazed, on a package being returned from Prof. Asa Gray marked "*Amphicarpœa monoica.*" I decided to watch the behavior of the plants more closely another year.

I now find the petaliferous flowers on these plants abundantly fruitful. In what may be termed the more vigorous racemes, the two lowermost flowers either have no petals, or have but a small vexilla projecting a little beyond the calyx. The next half dozen flowers, are perfect in every respect, and are fertile. The succeeding flowers usually fall without perfecting a legume. It may be noted that the legumes and calyx are different in these two instances, Fig. 1, shows the petaliferous and Fig. 2 the apetalous, forms. Thus we have three forms of legumes on the one plant, the hypogeous, which is short, thick and roundish at the end, Fig. 4, and these two now described.

The apetalous flowers can be scarcely classed as cleistogene, for there is certainly no pollen in many of them. In the few score I examined at this time, a few undeveloped stamens could be detected here and there. In the absence of positive demonstration, I should rather regard these as pistillate flowers, receiving their pollen from the petaliferous ones.

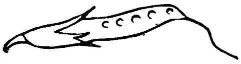

Fig. 1.

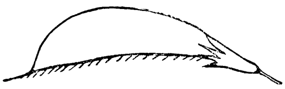

Fig. 2.

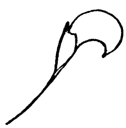

Fig. 4.

I do not find the flowers are adapted to cross-fertilization, except in the monœcious manner indicated. In the petaliferous cases the flowers are diadelphous—one stamen being wholly distinct from the rest. These are thoroughly united into a tube for very nearly their full length, little more than the connective of the anthers being free. The pistil, running up this tube, is about the exact length, and the stigma is imbedded in the thick mass of stamens, and completely covered by own-pollen. It is evident that no foreign pollen can possibly reach the stigma. So tightly held together is the mass of filaments, that when the fertilized pistil commences to expand, the ovarium bursts out at the base of the column, and as it grows, draws down through the staminate column, the style, this giving the stigma another full dose of its own-pollen. (Fig. 3.) It is a remarkable adaptation for self fertilization. Besides this close covering of the stigma by the stamens and column, the keel embraces the stamens so closely that even the "tickling" of the flower with a pin, simulating the action of an insect, fails to set them free. As soon as the ovarium begins to grow, and the flowering stage has reached the period illustrated in Fig. 3, the petals fall apart, and the pollen is liberated for the wind to carry it elsewhere.

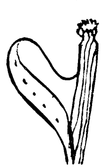

Fig. 3.

Persistent watching failed to note any insects at work, but numerous blossoms of *Impatiens fulva*, possibly afforded the greater attractions at the time of my observations. The bruised petals of *Amphicarpœa,* showed that, at some time during the day or night, insects were at work on the flowers.

The large vigorous blossoms on these plants were of a brilliant purple. The plants which I have seen with whitish-yellow flowers, in other localities, grow weaker than these. They also produce legumes from apetalous flowers on the climbing stems, but the locality is not near enough for me to watch, to see whether the petaliferous flowers bear freely or not.

Fruiting as these flowers do, on the climbing branches, at least, there are two-thirds fall without seeding. This cannot be from impotency of the pollen, or none would seed. Few leguminose plants, even when exposed to cross-fertilization, perfect more than a small portion of their flowers. Failure is from too great a draft on the nutritive powers of the plant. So many flowers cannot be properly fed, though properly fertilized by pollen. The remarks of Mr. Darwin on *Voandesia,* are no doubt just, changing the word cultivation so as to read "we should remember how often fertility is affected by circumstances."

I have already placed on record that the petaliferous flowers of *Viola cucullata* rarely produce seed under ordinary circumstances, but freely do so when the plant is growing on a dry rockery.

The points I regard as rendered certain by these observations are:

1. That the climbing stems, as well as the trailing ones, of *Amphicarpœa* bear apetalous flowers freely.
2. That these flowers produce a third form of legume.
3. That the petaliferous flowers, under circumstances favorable to nutrition, bear legumes as freely as leguminous plants generally.
4. That the petaliferous flowers are adapted solely to self-fertilization, and I think the probability is developed:

That the apetalous flowers are often fertilized by pollen from the petaliferous ones; and, so far the plant is arranged for as much cross-fertilization as other monœcious plants receive.

A contribution to the life history of Cephalanthus occidentalis.—

The pistils of *Cephalanthus occidentalis* are exserted more than an inch beyond the flowers, and as there are usually from one hundred to three hundred flowers in the button-like head, the mass has a well known trichodic appearance. I had never been able to see these extending themselves. The flowers were always either closed or fully expanded with the pistils to their full length. Satisfied that the opening took place during the night, I cut a few on the evening of

Aug. 1st. and placed them in a glass of water in my library, and watched their behavior.

The unopened flower, at 7 P. M., is very interesting from a small tooth bearing a black gland, seemingly situated in the axis between the lobes. It is really on the left hand side of each lobe, and gives to each division when carefully separated the outline of a mitten, where in covering the hand the thumb only is free. At 8 P. M. the lobes have parted, and what one would take to be a pair of united sagittate anthers, covered with pollen, have advanced just their length above the corolla-lobes. At 8·5, this length is doubled. The same progression continued till 8·30 when growth ceased, the slender "filament" having grown six lines in thirty minutes.

Examining next the four anthers in the open flower, they were found apparently destitute of pollen, and, remembering that systematists had found a close relationship between *Rubiaceæ* and *Compositæ*, the idea suggested itself that the stamens in the corolla were sterile, and that in some unaccountable manner two stamens had become as entirely consolidated with the style as in *Orchideæ*, and that only two fertile anthers were left, which had united and formed a cap wholly covering the stigma. Acting on the suggestion a pair of fine tweezers were placed under the seeming anthers, and a gentle lift took it off, as if it were a thimble in miniature, leaving a clear greyish-white ovate stigma behind. The sagittate form of an anther is so plain, and the four angles that these would make united back to back so apparent, that I am satisfied no one, at first thought, would take them for anything else than as described. Full of enthusiasm over the mystery I sent some to my friend Mr. Sereno Watson, to learn what he would think of the "missing link" in this pair of monodelphous anthers. His reply that he found some grains of pollen in the true anther sacs, and only pollen on the stigma, led me to look into the matter again, and I found he was right. The four anthers mature before the pistil takes its rapid start. At anthesis the anthers are pressed firmly over the stigma. When the growth of the pistil occurs, the stigma wipes out, almost clean, the entire mass of pollen, and so nicely as to retain the form of the anther lobes on the stigma as the style develops. I have since found that this simulation of the form of real anthers is not seen in the open air. The motion of the atmosphere or possibly the jar from the visits of nocturnal insects gives a rounded form to the stigma-covering mass.

After twenty four hours, a portion of the clear stigma is seen above the mass of pollen, showing that the stigma expanded a little after the growth of the style had been completed.

I think it is conceded that plants have not a time for the opening of flowers from which they never depart, and that exceptions have been noted in even very regular habits. But it may be stated in a general way that the flowers of this *Cephalanthus* open rapidly, soon after dark, and never during the day time.

The odor of the flowers is singularly grateful. They are visited by large numbers of insects for their nectar day and night. No pollen gatherers seem to work on them. There is indeed no chance to collect it from the stigma, no platform affords a facility for standing during collection. The pollen remains on the stigma till the whole dries away. It is one of the most complete adaptations for self-fertilization known to me outside of the Cleistogene class.

Interested in noting how this absolute in-and-in breeding affected productiveness, I subsequently found the flowers remarkably fertile. Numerous seeds were in every head examined. Carefully dissecting one, I found it had 279 flowers, of these 225 perfected seeds, and only 54 failed.

In describing *Cephalanthus occidentalis* in *Flora Cestrica*, Darlington describes the flowers as "five lobed;" most other botanists "four-parted." My flowers were mostly four, but many five-parted.

The glands between the lobes of the corolla appear to have been unnoticed. That the receptacle is "filiferous" has long been observed (Loureir's Flora of Cochin China, 1788), and Gray (Synoptical Flora of North America 1884) notes that these "setiform bractlets" between the flowers are glandular-capitate. Donn (Dichlamydeous Plants, 1834) notes "in the American species glands none in calyx or corolla." They are so easily noted in these specimens before me, that it is singular they should have been over-looked. There are four of these "setiforme bractlets" at the base of each floret, and they are slightly squamiform at the base. They are nearly alternate with the lobes of the calyx, starting from a little to one side of the sharp angle that terminates at the base of the division of the calyx. The setiform bractlet is just the length of the tube of the calyx, and if adherent to the calyx, the gland would be just where it is situated in the lobes of the corolla. No one can fail to see the gland on the corolla is the analogue of that on the setiform bractlet. We have no hesitation in concluding that there is primarily another series of bractlets between the calyx and corolla, and that they have become confluent with the corolla. On this theory the lobes of the corolla should be opposite and not alternate with those of the calyx. After this theory had suggested itself, examination of the flowers showed it was correct. The lobes of the corolla are opposite the lobes of the calyx.

The close relationship of Rubiaceæ to Compositæ has often been remarked on. There are some correspondences in these observations worthy of note:—

Mr. Darwin remarks (Effects of Cross and Self-fertilization, p. 173, 1877) that "*Compositæ* are well adapted to cross-fertilization," and Professor Asa Gray (*American Agriculturist*) adopts the same view, referring to the ray-florets as if they were flags to attract insects. Adaptation, is however, chiefly inferred from the fact that the stigma, pushed up through the column of anthers, and covered with pollen, generally cleaves at the summit. The interior faces thus seem destitute of pollen, and must receive it from some external agency. The author of the present paper has, however, shown by careful observation on the flowers of Chicory, that the pollen grains fall into the cleft as the lobes of the stigma diverge. Many experiments by enclosing flowers of different genera in fine gauze, resulted in the florets seeding just as well as when exposed to the visits of insects. He has, therefore, always contended that the supposed arrangements for cross-fertilization in *Compositæ* were deceptive, and that the species are generally closely self-fertilizers. In further support of this view he has called attention to the fact that in plants conceded to be dependent mainly on external aid for pollen, a large number of flowers never get fertilized at all, while in self fertilizers failure rarely occurs. *Compositæ* come squarely into this class. The hermaphrodite florets rarely—one might also add, if ever—fail to perfect their seed. The remarkable fertility of the self-pollenized florets in the heads of *Cephalanthus*, deserve to be noted in correspondence with the self-pollenized florets of *Compositæ*.

The "bractlets" at the base of the flowers, are the analogues of the scales on the receptacles of *Compositæ*.

The bractlets, or a cycle of floral parts similar to and succeeding bractlets, unite with the corolla-tube, and form intra-lobular teeth in *Cephalanthus*. May not certain forms of seta (*Helianthus, Heliopsis*, etc.) be bractea that have become confluent with the calyx, their apices forming the setaceous teeth ? It is difficult to determine this point from the want of correspondence in number (abortion?) of some of the parts; but it is worthy of note that in the two genera just named, and others, where these teeth exist, a tooth is always alternate with the main "lobe" that distinguishes the ray from the tubular floret.

I think it will be conceded that, given a very little arrestation, development, union or separation of parts as we find them in *Cephalanthus*, it would not be difficult to construct a Composite flower.

Amorpha canescens, Nutt.—*Amorpha fruticosa*, has leaves glandular pellucid punctate, the dots being irregular in size. The legumes are covered by very large glands, also irregular in size. In the leaves of *Amorpha canescens* the pellucid dots are also irregular, and in many leaflets so indistinct that one should scarcely note their existence, only that we are looking for them. In the legumes, however, the glands are large and abundant, and readily observed through the dense mass of woolly hair that envelopes them. The point is worth noting. The carpels, morphologically leaves, usually have many characters suppressed in the progress of development from the primordial leaf to the carpel; but here we find characters existing in a marked degree in the leaves of an allied species, and nearly suppressed in its own foliage, reappearing as a strong feature in the legume.

During anthesis many interesting points present themselves. The anthers are fully formed and exhibit their yellow surfaces through the bursting sepals, when they seem to have their further growth arrested, and the pistil only elongates. It extends to double the length of the calyx. This is the work of the first day of opening. The next day the stamens lengthen, but one at a time. As soon as the first one has reached the exact length of the pistil, another starts into growth, then another, until towards the end of the day's work all are of about equal length. Soon after reaching its final growth the anther sacs burst, and thus one after another, in regular succession, the pollen is ejected from the cells. On the third day the pistil recurves, the apex forming a right angle with the base, and usually having its stigmatic apex in among the withered stamens of the flowers lower on the spike. All this time, the only petal possessed by the flower, the vexillum, has remained nearly quiescent. It projects its beautiful blue tint just a little beyond the calyx, the second day, after the last stamen has made its growth; but it is not till the third day that it makes a growth in earnest, when it goes on rapidly, not, however, reaching quite the length attained by the stamens and pistil.

The observation worth recording here is that the bright corolla is often referred to in modern times, as being colored in order to attract insects to aid in the work of cross-fertilization. The colored corolla does not appear here until fertilization has been effected, which is evidenced by the recurving of the pistil. The orange-gold of the anthers would of themselves be sufficiently attractive; and the later effect of the vexillum, wholly superfluous, if mere attraction were the sole end nature had in view. Although the pistil matures a whole day before the stamens mature, the stigma receives the pollen often from the stamen of the same flower, or from those in the immediate vicinity, and which matured the day before, which is self-fertilization,—cross-fertilization being, according to Darwin, the reception of pollen from another plant. The flowers seem very grateful to the pollen gathering insects. After cleaning out the orange-colored pollen, from the woolly linings of the cell, by the insect, the empty white anthers, gave an additional interest to the orange and blue of the more perfect flowers.

The explanation of the late growth of the vexillum is evidently that growth is reflex—from the central axis downwards, as we see in *Liatris* and other *Compositæ*. After the axis, as represented by the pistil, has finished its growth, the spiral uncoils downward, and permits of the axial growths that the floral parts represent, beginning with the most advanced stamen, and running back to the petal, which of course would be the outermost verticil in the coil.

Oxybaphus hirsutus—*Oxybaphus*, says an old writer of the Linnean School "is a genus of the class *Triandria*." "The only known species is *Oxybaphus viscosus*. It is a native of Peru, and is nearly allied to *Mirabilis*, under which genus it is ranged by Cavanilles, but was made a distinct genus by L'Heritier, on account of its only having three stamina, and the calyx enlarged and peltate, attending the fruit." In those times to have three stamens was an essential charactcr of the genus, In Gray's *Manual*, *O. nyctagineus* being the only one described, the genus has "stamens mostly three." In Coulter's *Flora of Colorado* "stamens usually three" is the record. As it is stated of *Mirabilis* by Coulter "stamens usually five," it is evident modern authors, equally with the founder of the genus, look to the number of stamens as in some measure a generic character. So far as I can find in works to hand, the number of stamens is not specially noted in any description, except in the one case of *O. coccineus* in *Rothrock's Report of the Wheeler Expedition.* Choisey in DeCandolles *Prodromus* has "stamina 5" as one of the characters of the whole genus. In view of this uncertainty it is worth placing on record, that *O. hirsutus*, Sweet, always within my observations, has five stamens. I have had plants growing from seed gathered by me in Southern Colorado a number of years ago, and the plants uniformly have five stamens.

The flowers always open towards evening. On August 10th, I sat myself to watch their unfolding. At 4 P. M. one could just trace the pink color line, with a portion of a filament discernible; by 4·30 the stamens and pistil were fully exserted, over an inch in length beyond the perianth, the segments of the perianth were partially expanded, but were crumpled, and by 5 these were fully expanded, and the flower perfectly in bloom. Hundreds opened, but the anthesis of all was simultaneous. The involucre is three-flowered, but one opens first, and we may call this a central one. The two lateral open together the next day.

It is interesting to watch the expansion of the flower. The stamens in vernation are incurved. The anther seems to be caught in the imperfectly open flower. The filament, as it elongates, forms a loop. When the half hour of growth has been nearly reached, the perianth by that time expanding a little and, freeing the anther from pressure, the incurved portion springs suddenly forward, and instantaneously we have the long, straight, exserted stamen. In all that I noted the stamens proceeded thus: one at a time successively, the whole five occupying about two minutes to straighten out.

The flowers continue open all night; but commence to close by day-light in the morning.

I have noted on other occasions that some plants do not keep good time any more than some watches. I thought to repeat the observations on the evening of the 11th. Strange to say at 5 P. M. there were no more signs of opening than on the preceding day at 4. At 6 P. M. only one flower was open. At 7·30 they were all fully open as the day before at 5. It was a very dark and cloudy afternoon, heavy rain with lightning at 6·30. As most evening flowers seem favored by moisture and darkness, this contrary observation is worth recording.

The growth of the pistil is coincident with that of the stamens, and is of equal length. The anther cells burst at once on the stamen reaching its full length. The pollen is remarkably large, there being only about 25 grains in each cell. The stigma seems receptive co-incident with the maturity of the pollen. There is nothing to suggest any special arrangements for cross-fertilization. The flowers are odorless. Moths visit the flowers freely. The moth remained a long time feasting on a single flower, generally from two to three minutes. It used the mass of filaments with the style for a platform on which to work for the nectar at the base of the style. Its motions would tend to shake the pollen out into the flower's own stigma and aid in self-fertilization. Large numbers of the flowers on my plants are barren. Many have not one, some have but one, and rarely are there two seeds in a single involucre.

Besides the three flowers that are produced in each involucral cup, a branch occasionally proceeds from the same axis. The flowers are usually regarded as apetalous, but a close examination of an opening flower is strongly suggestive of an amalgation of the corrolline and calycine whorls in one perianth. As the flower is opening the bud presents what a superficial examination would regard as a five-cleft calyx, with green-lance-linear and hairy segments, and it would be a surprise to an original observer to find a mono-petalous corolla, wholly in one piece with what appeared to be a distinct calyx. At the apex of one of the segments, and which by the way are alternate with what should be petals, there are two small pin-like, white glands; at the apex of another one gland; and at the apex of a third a small and imperfect one. This indicates that the elementary parts forming the floral whorl did not coil rapidly on its spiral course; as also does the successive development of the stamens; we may reasonably look for some irregular flowers among its congeners.

Irritability in the Stamens of Echinocactus.—It has been long known that the stamens of many Opuntias are irritable or sensitive when fully expanded under a hot sun. I have placed on record that this character extends to other allied genera. This summer I noted that the stamens of *Echinocactus Ottonis*, were particularly irritable.

Diurnal opening of the flowers of Magnolia glauca.—My brother Joseph called my attention to the fact, that cut flowers of *Magnolia glauca*, in water in our office, opened at 4 P. M. I found this to be the case also with plants growing in the open air, no matter whether the sun was shining, or the sky cloudy. They open at 4 P. M. but close again before nightfall. The next day at 4, they open again, the anthers shed their pollen and then the petals close again. At 4 the third day they again expand, and continue expanded for some days till they fade.